FIRE/FUELS REPORT ADDENDUM

SAGEHEN PROJECT

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Introduction

In order to effectively respond to the suggestion from Sierra Forest Legacy to put prescribed fire only within the NE Sagehen goshawk PAC, three questions need to be answered:

1. Can you effectively introduce fire to the PAC without unintended consequences of higher fire severities while still meeting some fuel reduction objectives?
2. As per standard and guide 74 of the SNFPA Record of Decision, flame lengths, on average across the PAC, must not exceed 4 feet. Would introducing fire to the PAC with little or no previous treatment violate that standard?
3. If burning alone is not a viable option, what would no treatment to the NE Sagehen goshawk PAC mean for the overall landscape fuel strategy?

Methodology

Question 1: Creating a preliminary burn plan for the PAC is the only way to ascertain the viability of introducing fire to that area with minimal to no treatment beforehand. The first step is running scenarios in BehavePlus. BehavePlus is a fire modeling program used to inform burn plans. This program determines what weather and fuels conditions we can administer prescribed fire in while meeting objectives. BehavePlus provides expected flame length, rate of spread, containment status, tree mortality, crowning, spotting distance among others that are essential when authoring a burn plan. Typically one or two fuel models as well as weather and fuel moistures are used as inputs into BehavePlus. Although not as versatile as FlamMap, its ease of use has made it a standard during burn plan development, particularly on the Tahoe National Forest. BehavePlus can also generate burn windows for a prospective prescribed fire. These windows are essentially book ends of weather conditions where a particular burn plan can be implemented. The cold/wet end is the coldest and wettest weather conditions where fire would actually ignite and could be carried throughout the unit. The hot/dry end is the hottest driest conditions where fire would ignite and carry throughout the unit without rapid spread and high tree mortalities. Finally, outputs presented here are only looking at the effects of a forward spreading fire. Although a prescription may require a lighting pattern that facilitates lower intensity backing fire, topography and local wind patterns would make it impossible to eliminate forward spread. Therefore burn plans are required to account for the highest potential fire behavior that could occur with a particular set of fuel and weather conditions.

Question 2: BehavePlus will be used to initially quantify the average flame lengths across the PAC. However, since the Sagehen Fuels report primarily used FlamMap to quantify effects of treatments or no action, this analysis will also use FlamMap to both confirm flame lengths generated from BehavePlus runs and provide a spatial flame length analysis across the PAC. As described in the Sagehen Fuels report, FlamMap is a fire behavior mapping and analysis program that computes potential fire behavior characteristics (rate of spread, flame length, fire type and fireline intensity) over an entire FARSITE landscape for constant weather and fuel moisture conditions. FlamMap modeling provides a look at various aspects of potential fire behavior across the entire landscape of interest with all given weather inputs held constant at a given point in time. So, this means that the model burns every pixel on the landscape in the same instant. This scenario is not realistic, but it provides an effective way to see relative differences of fire behavior potential across the study area. Many fire behavior outputs are available. This analysis will only look at flame length, however, and will calculate its weighted average across the PAC.

Question 3: Farsite will be used to analyze how crucial the NE Sagehen goshawk PAC is to the overall fuels strategy. As described in the Sagehen Fuels report, Farsite is a fire behavior and growth simulator for use on Windows computers. It is used by Fire Behavior Analysts from the USDA FS, USDI NPS, USDI BLM, and USDI BIA. FARSITE is designed for use by trained, professional wildland fire planners and managers familiar with fuels, weather, topography, wildfire situations, and the associated concepts and terminology. Farsite generates similar outputs as FlamMap, however Farsite simulates the growth of the fire according to time steps determined by the user. Weather data is input according to an hourly "wind stream" file, which allows for input of wind speed and direction according to the hour of the day. Temperature and relative humidity values are input for the most active time of the day (roughly 1500), and the least active time of the day (roughly 0400). Farsite also allows the user to determine the ignition point of the fire. Considering no previous Farsite runs displayed in the Sagehen Fuels report isolate the PAC as untreated, it makes an additional Farsite scenario crucial for understanding whether or not that PAC, in its current condition, reduces the effectiveness of the overall Sagehen fuel reduction strategy.

Conditions

Fuels

BehavePlus requires the predominant fuel type of a particular area as well as the average canopy height, canopy base height, canopy bulk density, the most fire susceptible tree species and the upper diameter at breast height (DBH) limit for the model to predict mortality for.

Table 1 describes BehavePlus inputs used for the NE Sagehen goshawk PAC.

Table 1: BehavePlus Fuel inputs

Inputs	Cold or wet	Hot or dry
Fuel Model	TU5	TU5
Canopy Height in feet	55	55
Canopy Base Height in feet	5	5
Canopy Bulk Density	0.10	0.10
Mortality Tree Species	White Fir	White Fir
DBH in inches	20-40	20-40

FlamMap and Farsite both require two sets of data, fuel type and weather. Different fuel types help determine how a fire reacts to the amount of live and dead material in the model where weather informs the model on what climatic conditions the fire will be burning in. "Fuel types are defined as an identifiable association of fuel elements of distinctive species, form, size, arrangement, or other characteristics that will cause a predictable rate of spread or resistance to control under specified weather conditions" (NWCG glossary of terms). For example, a mixed conifer fuel type will burn differently than a long needle pine fuel type.

LANDFIRE Reference Database version 1.1.0, completed in 2011, was used to build the landscape data used in modeling for Sagehen Project. In order to perform fire behavior modeling with FlamMap and Farsite, several sets of spatial and tabular data must be assembled. Certain topography and fuel conditions are required to build a "Landscape file", the basis for the modeling programs. These topography and fuel condition files were obtained from LANDFIRE 1.1.0, 2011. Updates to fuel layer files were necessary to accurately represent areas recently treated, as well as areas to be treated in the near future.

The modeling assumes all treatment (silviculture and fuels) are in place for fire modeling. LANDFIRE National mapping was supported by a vast database of field-referenced data. The LANDFIRE Reference Database (LFRDB) used for LANDFIRE National product development included vegetation and fuel data from approximately 800,000 geo-referenced sampling units located throughout the United States. This data was amassed from numerous sources and in large part from existing information resources of outside entities, such as the USFS Forest Inventory and Analysis (FIA) Program, the USGS National Gap Analysis Program, and state natural heritage programs. Landfire 1.1.0 was used because it is the best representation and newest vegetation dataset available. More information is available on the Landfire website: http://www.landfire.gov/

Weather

Burn window weather has been determined for this area after several previous experiences of similar conditions in similar topographic locations.

Table 2: BehavePlus Weather inputs

Inputs	Cold or wet	Hot or dry
1-h Fuel Moisture	13	9
10-h Fuel Moisture	14	10
100-h Fuel Moisture	15	11
Live Herbaceous Moisture	50	50
Live Woody Moisture	50	50
Foliar Moisture	200	200
20-ft Wind Speed (upslope)	15	25
Wind Adjustment Factor	0.2	0.2
Air Temperature	65	75
Fuel Shading from the Sun	50%	50%
Slope Steepness (average)	30%	30%

In order to understand the relevancy of the NE Sagehen goshawk PAC in the overall Sagehen Project fuel strategy, a new Farsite ignition scenario will be run that could affect that portion of the Project area. As with all Farsite runs in the Sagehen fuels report, 90th percentile weather will be used during the duration of the simulation as outlined in the Tahoe National Forest Land and Resource Management Plan 1990, "The 90th percentile weather or average worst weather conditions will be used to represent the specific weather factors for planning purposes. This means that only 10% of the observed weather days for the past 10 years have had more severe fire weather than those used for determining fire intensity levels."

Weather and fuel moisture data was obtained for the Stampede Remote Area Weather Station (RAWS). This data was accessed from an online database, and analyzed using FireFamilyPlus software to derive 90th percentile weather conditions for the specific parameters needed for Farsite modeling. FireFamilyPlus (FFP) is a comprehensive Windows-based program that analyzes and summarizes an integrated database of fire weather and fire occurrence. FFP can be used to calculate fire danger rating indices and components, summarize both fire and weather data, and offers options to jointly analyze fire and weather data. More information is available on the FireFamilyPlus website: http://www.firemodels.org/index.php/national-systems/firefamilyplus

Table 3 displays 90th percentile weather conditions for the National Fire Danger Rating System (NFDRS) weather station at Stampede RAWS from 1991–2011 which was used to inform Farsite modeling.

Table 3: 90th percentile weather from 1991–2011 for Stampede Weather Station, Tahoe National Forest, California

Maximum Dry Bulb (F)	82
Minimum Relative Humidity (%)	10
Maximum Wind Speed – 20'	17
1-hour fuel moisture (%) (dead)	2
10-hour fuel moisture (%) (dead)	4
100-hour fuel moisture (%) (dead)	7
Live Herbaceous fuel moisture	31
Live Woody fuel moisture	69

Analysis

Question 1:

The following two tables (table 4 and table 5) represent the BehavePlus outputs of the two burn window weather conditions outlined in table 2.

Table 4: BehavePlus outputs for cold prescription

Cold Prescription Outputs		
Fire conditions	**Units of measure**	**Outputs**
Rate of Spread (Surface Fire)	Chains per hour	7.2
Flame Length (Surface Fire)	feet	6.4
Critical Surface Intensity	Btu/ft/s	229
Transition to Crown		Yes
Crown fire Flame Length	feet	58.4
Crown Fire ROS	Chains per hour	42.4
Active Crown		No
Fire Type		Torching
Scorch Height	feet	38
Probability of Mortality	%	41
Probability of Ignition (PIG)	%	18

Outputs highlighted are key areas to look at when writing a burn plan. The probability of ignition (PIG) is particularly important for the cold/wet end of a burn window. When PIG is under 20% it is difficult to get fire to carry. Therefore, this cold prescription PIG shows that attempting to light a prescribed fire in the PAC with weather that is any colder or wetter than what is outlined in table 2 would not result in successful ignition and would not meet prescribed fire objectives. Even with a low PIG, once fire does ignite, it will still have flame lengths, on average, of 6.4 feet. Tahoe National Forest fire managers typically do not approve a burn plan with flame lengths, on average, exceeding five feet because of the difficulty to control and safety concerns resulting from higher fire intensities. Therefore even at the cold/wet end of the burn window where fire would carry, the high average flame lengths would keep this burn plan from being approved by the Tahoe National Forest fire leadership. High scorch heights and mortalities of large trees confirm that fire intensities would be too high for control with fire personnel and would result in unintended consequences within the PAC.

Table 5: BehavePlus outputs for hot/dry prescription

Hot Prescription Outputs		
Fire conditions	**Units of measure**	**Outputs**
Rate of Spread	Chains per hour	12.6
Flame Length (Surface Fire)	feet	8.5
Critical Surface Intensity	Btu/ft/s	229
Transition to Crown		Yes
Crown Fire Flame Length	feet	101.9
Crown Fire ROS	Chains per hour	95.7
Active Crown		Yes
Fire Type		Crowning
Scorch Height	feet	62
Probability of Mortality	%	99
Probability of Ignition (PIG)	%	35

At the hot/dry end of the prescription, BehavePlus predicts intensities would be even higher. As stated above, Tahoe National Forest fire managers typically do not approve a burn plan with flame lengths, on average, exceeding five feet because of the difficulty to control and safety concerns resulting from higher fire intensities. With flame lengths averaging 8.5 feet across the unit, this burn plan would most likely not be not be approved by Tahoe National Forest fire managers.

Question 2:

As shown in table 4 and 5, BehavePlus outputs have average flame lengths of 6.4 feet for the cold/wet end and 8.5 feet for the hot/dry end.

In order to confirm BehavePlus analysis, FlamMap was also run with the same weather scenarios. Table 6 shows those outputs.

Table 6: FlamMap outputs for prescribed fire weather

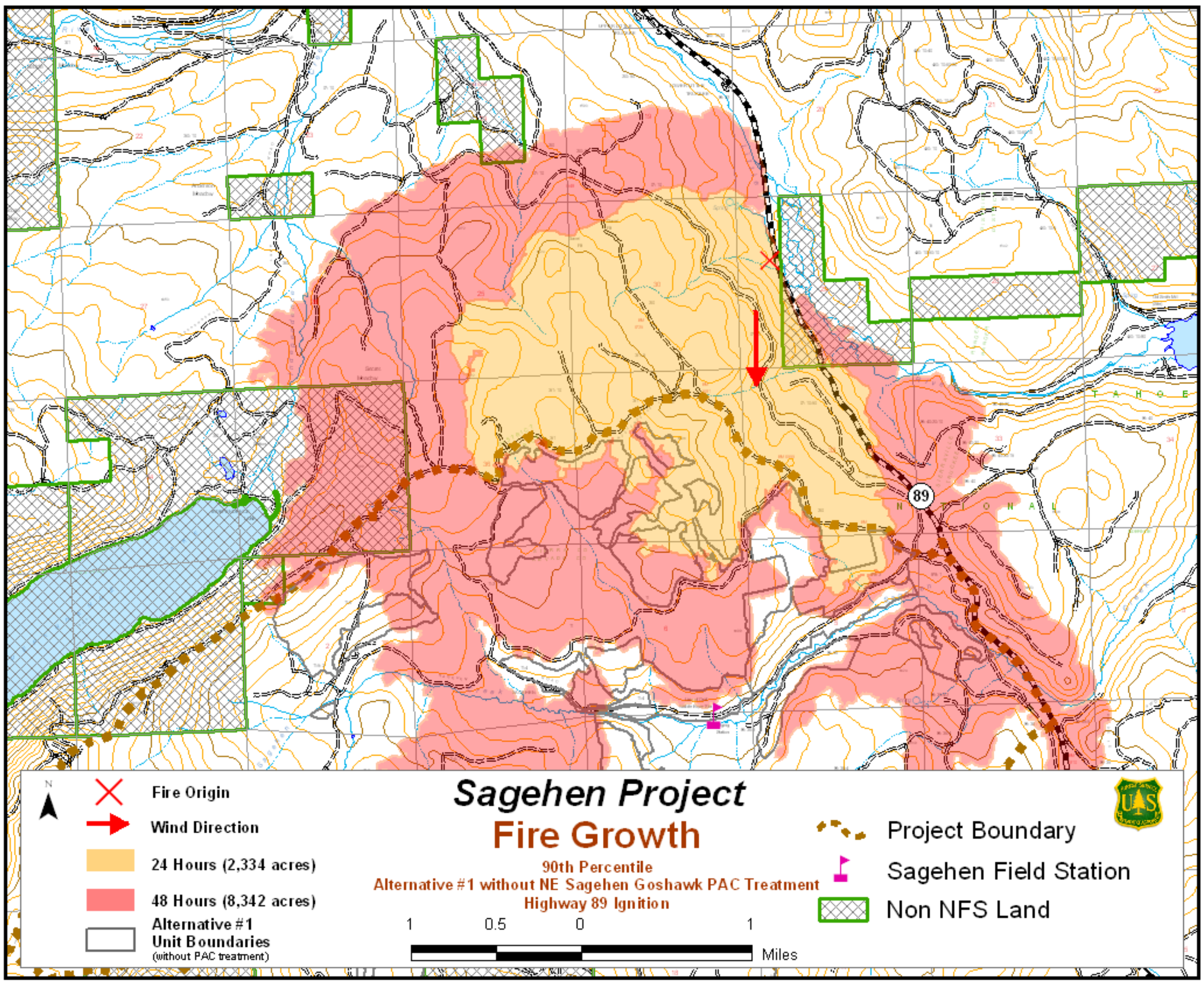
	Cold/Wet Prescribed Fire Weather	**Hot/Dry Prescribed Fire Weather**
PAC Weighted Average Flame lengths	10 feet	63 feet

Both average flame lengths from both fire behavior models show flame lengths that exceed the metric set forth in standard and guide 74 of the SNFPA record of decision. Because high fire intensities as shown in tables 4, 5, and 6 would induce high tree mortalities, adverse effects on habitat in the PAC would likely be significant.

Question 3:

As stated in the need for the Sagehen Project Environmental Assessment, there is a threat of a wildfire starting along Highway 89, which could be driven into the Basin by winds from the north/northeast (EA, page 13). Map 1 shows a likely potential fire scenario progressed in Farsite as if the NE Sagehen goshawk PAC receives no treatment while the surrounding units are treated as outlined in Alternative 1. The ignition occurs adjacent to a heavily traveled highway with 90th percentile weather conditions outlined in table 3 and a northerly wind direction.

Map 1: Hwy 89 ignition with a North wind – untreated PAC



Map 2 shows a likely potential fire scenario progressed in Farsite as if all units and the 160-acre portion of the NE Sagehen goshawk PAC in Unit 38 receives treatment as outlined in Alternative 1. The ignition occurs adjacent to a heavily traveled highway with 90th percentile weather conditions and a northerly wind direction.

Map 2: Hwy 89 ignition with a North wind – Alternative 1

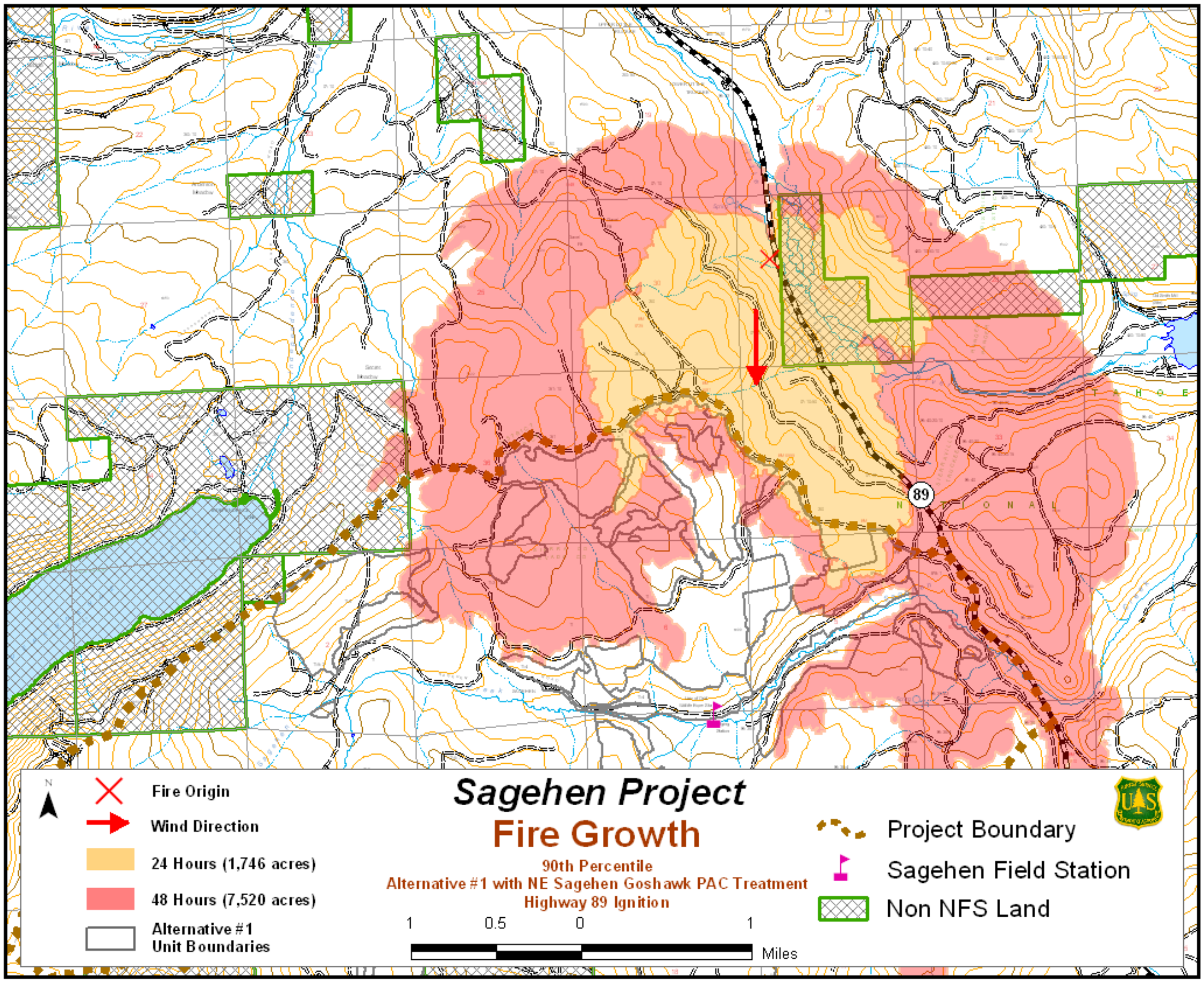


Table 5 then shows the acres burned at a specific time after ignition.

Table 7: Acres burned with ignition at Hwy 89 with a north wind under 90th percentile weather conditions

	Acres burned after 24 hours	Acres burned after 48 hours
Untreated PAC	2,334	8,342
Alternative 1	1,746	7,520

A comparison of these two fire scenarios exemplify the importance of the NE Sagehen goshawk PAC as part of the landscape fuels strategy of the Sagehen Project, particularly in protecting the U.C. Berkeley field station. For example, as shown in Map 1 (untreated PAC), a fire that started on highway 89 with a north wind during 90th percentile weather conditions could reach and move through the NE Sagehen goshawk PAC within 24 hours. Once established, FlamMap predicts, even with weather somewhat less than 90th percentile (table 2), high flame lengths which would translate into high amounts of tree mortality and most likely loss of significant habitat of that PAC (table 6). In 36 hours, the fire would be established in the Lower Sagehen goshawk PAC. Previous FlamMap runs found in the Sagehen Fuels report (p.47, p.54, p.61) show similar high flame lengths and probable significant habitat loss. Within 2 days, the fire would reach the field station. Although proposed treatments would allow for safe egress of the public and field station personnel, close proximity high flame lengths would most likely spot over and move through the field station with probable property loss. Due to the high flame lengths, suppression would be challenging, and suppression personnel would only be able to engage the fire indirectly, which would allow for further fire growth.

Map 2 portrays different Farsite modeling results whereby the 160 acres treated in the PAC, along with the strategic positioning of the other treatments, reduces fire behavior once it comes in contact with Sagehen Project units. Once in treatment units, the lower fire intensities (indicated by flame length, rate of spread, and fire type) as outlined in the Alternative 1 analysis within the Sagehen Fire/Fuels Report would have much less effects within the PAC and would most likely minimize habitat loss. Further, lower fire intensities would most likely allow for direct suppression tactics to occur before fire reached the Lower Sagehen goshawk PAC and thus would insulate the field station from high severity fire in this scenario.

Table 7 quantifies fire growth at a certain point in time. If the PAC remained untreated, acres burned would be about 2,334 acres within 24 hours and 8,342 acres by 48 hours even if all the other units were treated as described in Alternative 1 including unit 38 emphasis area 7. If the 160 acres in the PAC are treated as described in Alternative 1, acres burned under this scenario are reduced, most importantly within the Project Area: 1,746 acres are burned by 24 hours and 7,520 acres are burned within 48 hours in this particular ignition scenario with all Alternative 1 treatments implemented. Comparing the outputs from the total fire growth for these two scenarios indicates modest differences in total acres burned. It should be noted that these outputs are based on randomized factors, primarily the location of simulated spot fires. The FARSITE run for Alternative 1, generated a spot fire to the east of Highway 89 early in the model run (see Map2, north-east corner), which allowed for much greater fire growth in that area compared to the model run with the untreated PAC (Map 1). Due to the FARSITE Model's random assignment of factors that influence the modeled fire spread, the total acreage burned needs to be considered in the context of these factors.

The Farsite modeling results displayed in Map 1, Map 2, and Table 7 exemplify the importance of the NE Sagehen goshawk PAC in the overall Sagehen fuels treatment strategy. Without treatment of the PAC, coupled with no treatment within the other 4 designated PACs, there is an increased likelihood of a large stand replacing fire that could substantially alter habitat and threaten people and property. By treating the NE Sagehen goshawk PAC as described in Alternative 1, the probability of a fire coming into the basin from the north and becoming established as a crown fire is diminished. Lower fire intensities increase opportunities to utilize all suppression tactics, which could allow for control before fire spread into the lower Sagehen goshawk PAC and then on to the field station.